# Dare to Compare Real-time, Personal, Wearable Aerosol monitors?

**With So Many Real-Time Personal Wearable Monitors on The Market What Should Users Evaluate before purchasing?**

Depending on who is asked this question, the top two answers are probably specifications and price. While price certainly matters in today's economy, it cannot dictate the performance or capabilities of an instrument, although it can be used as indicator, in some circumstances. Specifications on the other hand, are valid metrics for evaluating an instruments capability.

Not every manufacturer publishes exact specifications. If this is the case, which specifications should be requested, researched and evaluated? Let's start with the basics. An active, personal, wearable particulate & aerosol monitor is comprised three main parts; the pump, the sensor and the sampling inlets. The following paragraphs outline the importance of these components and pose questions the manufacturer.

**Pump:**
*Is pump flow compensated?*
*Is the instrument a compliance monitor?*
*Can the pump account for back pressure from filter loading?*
*Can the pump account for temperature, humidity and atmospheric differences?*

If the pump in the real-time detection instrument (RTDI) is not flow compensated, the instrument will not be a compliance monitor. Flow needs to be as accurate as possible because **when flow varies results vary.**

If the RTDI is not a compliance monitor this typically results co-locating instruments, in which the worker wears two instruments; the compliance monitor worn on one side of the body and the and the RTDI on the other. There are several peer reviewed journal articles available pertaining to the varying results of co-locating instruments due to extraneous variables like body orientation, wind direction and the like. Having a compliance monitor that is also a direct read instrument, offers reliability, precision, and is a cost saving measure, while being less intrusive and burdensome to the worker.

While, specifications are given under laboratory conditions, usage in the real-world does not offer such control. Additionally, if the RTDI accepts filters, they are generally not used when determining specifications. Both environmental factors and filter sampling methods can have an effect on flow rate.

Temperature, humidity and atmospheric pressure impact flow rate. While users cannot control environmental biases, manufactures can control the pump. Having a fully compensated pump compensates for these variables and is typically stated in the specifications and expressed as a percent set- point after calibration to desired flow.


*Figure 1: HAZ-DUST HD-7204 Real-Time Compliance Monitor*

Filter loading is when media builds on the filter and back pressure increases. This not only affects the longevity of the pump but also the flow rate. Because there is so much variation in filter types, specifications are given without filters. However, a flow compensated pump will be able to maintain a steady flow rate regardless of the filter material, pore size or back pressure. When the pump exceeds the specification, a flow compensated pump will fault alerting the user.

Another specification regarding the pump that should be researched prior to purchase is the flow rate. If the RTDI accepts filters the this becomes increasing important. A lower flow rate requires a longer duration of sampling. This can be problematic depending on the threshold levels. Take silica for example, the current PEL of silica is 50 ug/m3 for an 8-hour shift. To someone unfamiliar with dust concentrations, imagine a pile of dust the size of a standard pencil eraser. If you took this 'pencil eraser' amount of dust and put it in a box 3 ft X 3 ft X 3 ft this would be over the current PEL of 50 µg/m3. (Courtesy of a CIH through AGC in Houston, TX). Having a RTDI with a low flow rate can be a serious disadvantage for collecting filter samples.

*Figure 2: Accepts any ISO pre-weighed laboratory 37mm cassette.*

If the RTDI does not accept pre-loaded cassettes this only exacerbates the problem as sample is lost due to filter handling. Filter substrates must be protected from contamination prior to, during and after sampling. (Landsberger and Creatchman, 1999). Particles can also fall off filters during movement from the field site to the laboratory (Dzubay and Barbour, 1983). Inaccurate results can increase workers risk. A RTDI should have the ability to accept pre-loaded, 2 or 3-piece filter cassettes, and the ability for open and closed faced sampling. Allowing the filter to remain in the cassette protects the sample from damage or loss of material, as well as improves the efficiency of the analytical process. (Cauda, 2021). It is best practice for the RTDI to minimize filter handling by accepting pre-loaded cassettes from a certified laboratory that allow open or closed faced sampling according to the regulations.

In addition to filter handling, the flow rate will affect the filter lab results. Filter samples are eventually sent to a lab for analysis. The lab requires the total volume of air for each sample submitted. It is imperative for accurate lab results that the flow rate is a known constant and the pump should be able to account for back pressure and filter loading. As stated earlier, when flow varies, results vary.

When a non-compliance pump is used, best practice suggests that the user post-calibrate flow from the field with the sampling inlet attached. This extra step is not required, when using a flow compensated pump. Skipping this step avoids training workers, carrying extra equipment to the site and valuable resources i.e. time and money. Again, it is best to use a flow compensated pump when possible.

*Figure 3: User accessible optical sensor for easy cleaning and maintenance.*

**Sensor:**

*Is the sensor mounted in the OSHA defined breathing Zone?*
*Is the optical sensor serviceable by the user?*
*Can the sensor accept pre-weighed filters?*
*Can the sensor accept 37mm or 25mm filter cassettes?*
*Placement matters*

In order to obtain the most accurate representation of workers risks, the sensor should be mounted in the OSHA defined breathing zone. When a sensor is mounted on the hip, there is a particle loss, as inner wall deposition occurs. Inner wall deposition, simply stated, is when particles stick to the tube as air is being drawn in from the breathing zone to the sensor. Using the 'eraser of silica' example it is easy to understand why minimizing inner wall deposition is important.

*Figure 4: ISO Validated pre-loaded with validated*

An instrument needs to be versatile to users in various regions of the world. For example, using a 37mm filter is common practice in the United States, in other regions of the world 25mm is more commonly practiced. In today's day and age neither an instrument nor its manufacturer should be ethnocentric. Air quality is a global concern. When comparing specifications, ask if the instrument can accept both 37mm and 25mm pre-weighed filter cassettes.

Real-time light scattering sensors, in laymen terms, is a beam of light being filtered through a lens and then read by a detector. Over time, the optical lens will get dirty/dusty. Once the optical lens is coated with dust, the instrument does not offer an accurate reading of the sampled air stream, thus throwing the instrument out of calibration. The amount of time it takes for a lens to be dirty depends on sampling conditions. It could be a year's time or it could be within a week, it depends on the concentration level. (*The instrument should always be used with the concentration range specified and intended use).* It is important that the user has a method for checking the PM calibration and for cleaning the optics. Often times when users refer to 'calibration', they are referring to flow calibration. Flow calibration is important but what about the PM calibration? How do you know if the instruments sensor is properly calibrated?

The RTDI should offer a PM calibration verification accessory. This accessory allows the user to know that the sensor is still +/- 10% of factory calibration. If it is not, then the sampling should not take place. If the Calibration Span Reference indicates that the instrument is not within factory calibration, then the user should be able to take action without interference from the manufacturer. Often times a simple cleaning of the optical lens will correct the problem. The user should be able to access the sensor and clean the optical lens.

*Figure 5: ISO Validated GS-3 Cyclone for Respirable*

**Sampling Inlets:**
*Are the sampling inlets validated?*
*Can the instrument adhere to regulatory standards?*
*Can the instrument monitor inhalable size fraction?*
*Is the inlet going to get clogged?*
*Placement matters*

The last 'piece of anatomy' discussed is the sampling inlets. As stated, the sensor and filter cassette should be mounted in the OSHA defined breathing zone. Where better to place a sampling inlet, then also attach it to the sensor?! Attaching an inlet to the sensor, allows for minimal inner wall deposition and a more accurate reading.


*Figure 4: ISO Validated IOM for Inhalable*

A sampling inlet should be in harmony with the flow rate of the pump. For example, OSHA's ISO Standard 7708 Silica rule for Respirable dust sampling, specifies a 50% cut off for 4um respirable size fraction. While researching specifications, it is important to ask the manufacturer or reseller if the personal air monitor offers a validated sampling inlet to fit this regulation, like the GS-3 cyclone or does the instrument offer any validated inlets?

Another size fraction of interest for personal monitoring is the Inhalable size. Can your instrument monitor a true inhalable size fraction? There is important distinction between a manufacturer stating they offer inhalable versus a true inhalable. Some instruments will display a value for inhalable. There is likely an algorithm in the instrument that offers a predictive inhalable size fraction. However, if you look at the air intake, the opening is too small for a 10um particle size, which is the Inhalable size. In fact, the air intake nozzle itself, operates as a size selector squeezing the air stream into a tiny opening. It is best to use a validated sampling inlet designed for Inhalable and place the sampling inlet directly on to the sensor.

# DARE TO COMPARE ANY REAL-TIME PERSONAL MONITOR AGAINST THE HAZ-DUST® MODEL HD-7204.

The HAZ-Dust Model HD-7204 is the only real-time personal monitor on the market to offer:

1. **Flow Compensated air sampling pump**
   a. Load, Temperature, and altitude compensated.
   b. Sampling Flow Rate: 1-5 LPM
2. The pump maintains flow underload within ±5% as follows: 55 inches H2O @ 2.5LPM

3. **ISO Proven & Validated Sampling inlets**
   a. Inhalable: IOM Meets the ISO 7708/CEN inhalable criteria with validated performance
   b. Respirable: The GS-3 Respirable Cyclone is operated at 2.75 L/min to conform to the ISO 7708/CEN respirable criteria specified in the 2016 OSHA rule on respirable crystalline silica.

4. **Pre-weighed 3-piece filter cassettes**
   a. Minimize Filter handling.

5. **25mm and 37mm filter option**
   a. Global differences

6. **Miniaturized sensor mounted in the OSHA defined breathing zone**
   a. Sample air where it matters


7. **User serviceable**
   a. Empower the customer with serviceability by allowing optical cleaning
      i. - Saves time and money.
      ii. Self-Diagnostics- No need to send back annually with user severability.
      iii. Fast swap battery packs.

8. **Calibration Span Reference**
   a. The only way to determine your PM sensor is calibrated and data is valid.

9. **Real-time and Compliance monitor in one instrument**
   a. Resource Management: cost saving & time saving

# When you are proud of specifications you publish them. Please visit our website for a full list of specifications.

https://environmentaldevices.com/wp-content/uploads/2022/04/Brochure_HAZ-DUST_HD-7204_-0422.pdf

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